Steep Cut Slope Composting: Field Trials and Evaluation

by

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Plot Construction Report

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INTRODUCTION

This Post Plot Construction report is submitted to the Montana Department of Transportation (MDT) for the Steep Cut Slope Composting: Field Trials and Evaluation project. It includes reporting for Task B and Task C in the research proposal, both of which have been completed. Task B was the test site selection and location and Task C was the test plot construction.

This research project has two primary objectives:

- evaluate compost performance using surface applied rates between 0.32 centimeters (cm) (0.125 inches (in)) and 1.27 cm (0.5 in). This phase of the research will establish minimum quantity recommendations to be used on steep cut slopes based on vegetation performance and erosion control, and
- assess the effectiveness of various tackifiers, erosion control fabric and netting in retarding wind and water erosion of compost on steep slopes.

To accomplish these objectives, Tasks B and C were designed to:

- conduct reconnaissance of the proposed test site 25 kilometers (km) (15 miles (mi)) west of Bozeman along Montana (MT) Highway 84 to assure its utility for constructing the various test plots (Task B), and

- prepare the site and implement the experimental treatments before the onset of winter weather (Task C).

This project is a companion project to earlier work performed by Montana State University (MSU RRU 2007) evaluating compost application and incorporation on steep cut slopes for MDT. The earlier work evaluated compost application at rates of 2.5 cm (1 in) and 5 cm (2 in). It also evaluated the relative effectiveness of surface applied compost blankets versus compost incorporated into the surface soil. Test plots were built in northwest Montana on glacial till and in southeast Montana on marine shale parent material.

RESEARCH

Task B: Test Site Selection and Location

A test site was located approximately 25 km (15 mi) west of Bozeman on MT Highway 84 (Figure 1). This road reconstruction project was completed in 2002. Steep slopes were cut into tertiary-age sedimentary parent material. Slopes did not receive a topsoil application before seeding during post-construction reclamation. In 2008 these slopes were nearly devoid of vegetation; approximate canopy cover ranged between 1 – 5 percent across the test plots.

In this location, MT Highway 84 is aligned on an east-west axis providing the opportunity for the establishment of test plots on both north-facing and south-facing slopes. The cut slopes where test plots were constructed are between 64 and 71 percent slope in steepness. Slope length ranged between 12.2-18.3 meters (m) (40-60 feet (ft)). It was determined that the 22 test plots required by the project could be constructed in this location with spacing of at least 1.5 m (5 ft) between each of the plots.

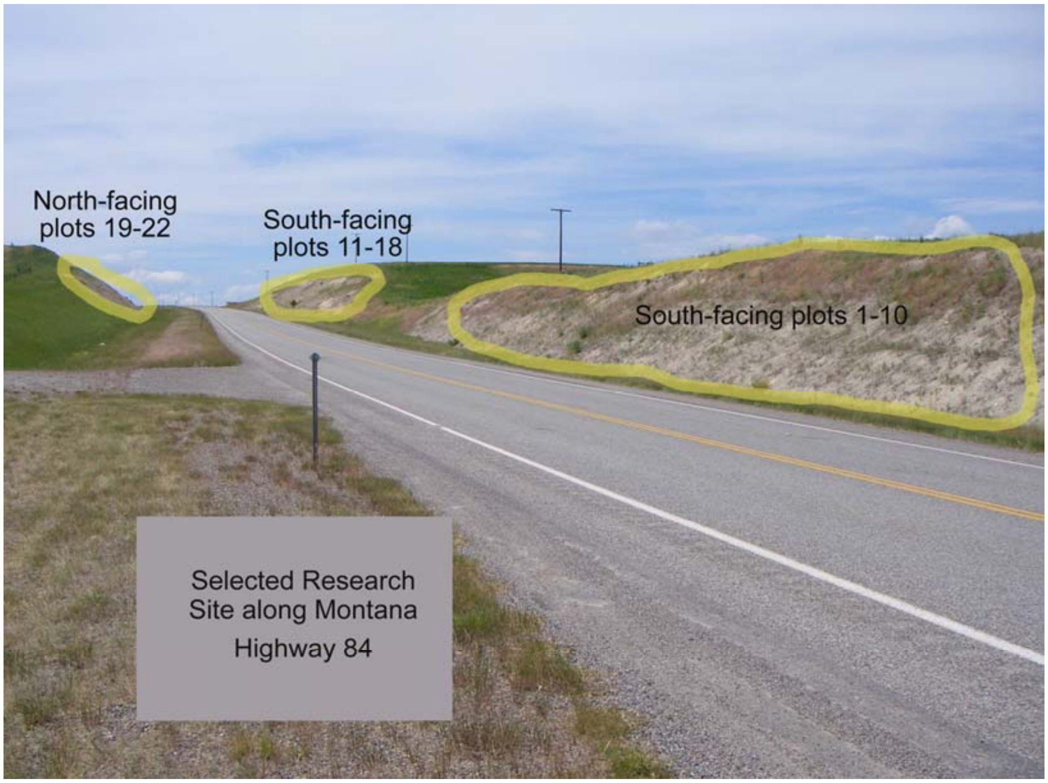
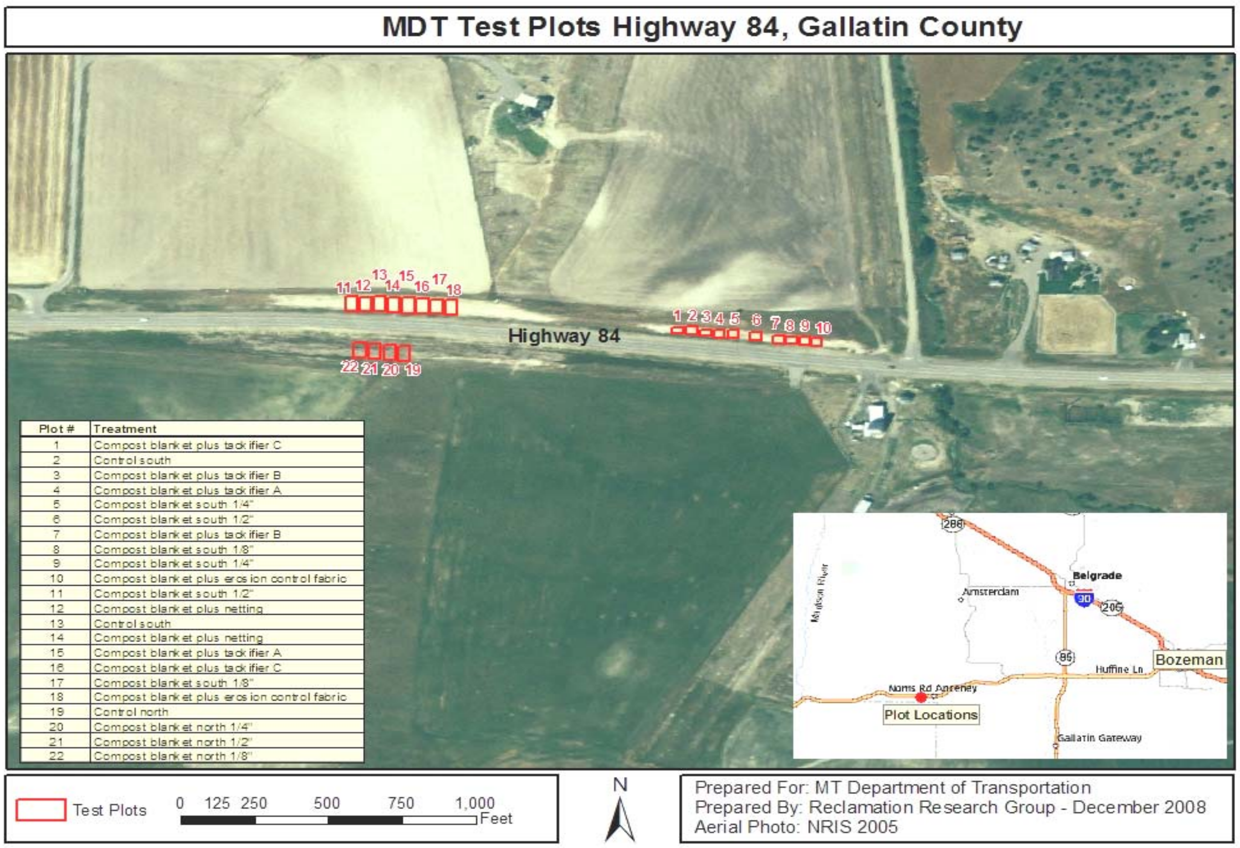


Figure 1: Roadside overview of research site location along Montana Highway 84

The landscape adjacent to the research site is characterized by gently rolling terrain with well developed agricultural soil currently used for small grain crops or rangeland (Figure 2). Topsoil was not replaced on the steep cut slopes used for the test plots. The parent material is comprised of tertiary-aged valley fill between 2.5 and 65 million years in age and typified by semi-consolidated sand, silt, clay and intermittent fine gravel deposits (English, 2007). Weathering of these weakly consolidated bedrock materials after road construction has resulted in a variable depth of unconsolidated soil ranging in depth from 1 to 10 cm (0.4 to 4 in).



Plot #	Treatment
1	Compost blanket plus tackifier C
2	Control south
3	Compost blanket plus tackifier B
4	Compost blanket plus tackifier A
5	Compost blanket south 1/4"
6	Compost blanket south 1/2"
7	Compost blanket plus tackifier B
8	Compost blanket south 1/8"
9	Compost blanket south 1/4"
10	Compost blanket plus erosion control fabric
11	Compost blanket south 1/2"
12	Compost blanket plus netting
13	Control south
14	Compost blanket plus netting
15	Compost blanket plus tackifier A
16	Compost blanket plus tackifier C
17	Compost blanket south 1/8"
18	Compost blanket plus erosion control fabric
19	Control north
20	Compost blanket north 1/4"
21	Compost blanket north 1/2"
22	Compost blanket north 1/8"

Figure 2: Site location map and test plot layout at research site, Montana Highway 84.

Task C: Test Plot Construction

Based on the experimental design for this research project (Table 1), 22 plots were laid out at the research site. Plot construction occurred on 11-14 November 2008. Four plots were located on the north-facing slope (Figure 3) and 18 were located on two separate south-facing slopes. Eight of the south-facing plots were placed across the highway from the four north-facing plots (Figure

4) and the 10 other south-facing plots are located together approximately 200 m to the east (on the right in Figure 5).

Table 1: Experimental design for compost research plots on MT Hwy. 84.

Treatment	Equipment		Aspect	Number of Plots				Total
	Blower Truck	Hydromulch Truck		Compost Application Rate 0	1/8 " (0.32 cm)	1/4" (0.64 cm)	1/2" (1.3 cm)	
Control	No	No	South	2	0	0	0	2
Control	No	No	North	1	0	0	0	1
Compost blanket	Yes	No	South	0	2	2	2	6
Compost blanket	Yes	No	North	0	1	1	1	3
Compost blanket plus tackifier A (guar based)	Yes	Yes	South	0	0	0	2	2
Compost blanket plus tackifier B (dirt glue)	Yes	Yes	South	0	0	0	2	2
Compost blanket plus tackifier C (synthetic)	Yes	Yes	South	0	0	0	2	2
Compost blanket plus erosion control fabric	Yes	No	South	0	0	0	2	2
Compost blanket plus netting	Yes	No	South	0	0	0	2	2
Total Number of Plots				3	3	3	13	22

Figure 3: View of four north-facing plots that are directly across the highway from the eight south-facing plots. The furthest plot to the east (left) as shown in the image is a control plot without compost application. Close inspection of the photo shows orange stakes and paint marking the outline of plot 19 (untreated control).

Figure 4: View of eight south-facing plots that are across highway from the four north-facing plots. Plot 11 is shown furthest to the left in the image (dark colored) while plot 18 is most distant (to the right or east) covered by a tan colored erosion control blanket.

Figure 5: View of ten south-facing plots that are on the east end of the research site. Plot 1 is furthest to the left in the image (dark colored) and plot 10 is most distant (to the right or east) with a tan colored erosion control blanket.

Plot layout and dimensions were adjusted to reflect the amount of the slope available for each of the 22 test plots. Typical plot widths were 9.1 m (30 ft) with a 1.5 m (5 ft) buffer between adjacent plots. Each test plot was built along the entire length of the slope from just above the roadside ditch at the bottom to either the top of the slope or to the edge of existing vegetation near the top. Some of the cut slopes had enough soil pushed down from the top that allowed for the establishment of perennial grasses on the steep cut slope. Test plots were bounded at the top to exclude any of this existing vegetation. As a result, this made slope length for each test plot of varying dimensions.

Several steep cut slope areas were omitted from research plot utilization when bedrock outcrops were near the surface or where perennial vegetation occurred in patches throughout the slope. Images of each test plot before and after implementation of the experimental treatments are shown in Appendix A.

The selection of which test plots received which experimental treatment was randomized. The 18 south-facing plots received different experimental treatments or served as a control plot based on the use of software for random number generation. Similarly, the four north-facing plots were selected for different depths of compost or as the control plot based on the use of random number generating software.

A plot construction contract was let to Quality Landscape Seeding, Inc. of Plains, MT (Quality). Quality provided the compost, netting, erosion control fabric, stakes, equipment (hydromulch and blower trucks), laborers, and the three commercially available tackifiers that were selected by the MDT Reclamation Specialist.

The test plots receiving experimental compost retention measures were constructed using a 4 step process:

1. Seedbed preparation
2. Seeding of plots with a native grass seed mix via a broadcast seeder
3. Compost applied using the blower truck
4. Compost retention measure applied to the compost blanket

For test plots evaluating different compost thicknesses and not employing a compost retention measure, only steps 1 through 3 were needed. For the three control plots, only steps 1 and 2 were necessary.

Seed Bed Preparation

This lane widening road project was completed in 2002. By the autumn of 2008 these slopes remained nearly devoid of vegetation. Some sparse vegetation was evident on the test site (Figure 6). The MDT Reclamation Specialist conducted an ocular sampling to characterize the vegetation on the site on 4 November 2008. At this time of year, all vegetation was senescent at the time of seed bed preparation. Vegetation cover was less than 5 percent and comprised principally of weedy species and remnants of the seed mix used after construction of the road widening project in 2002. The dominant desirable species observed was slender wheatgrass, *Elymus trachycaulus*. These plants were widely spaced and comprised less than 1 percent cover. The dominant invasive species observed was cheatgrass, *Bromus tectorum,* and several spotted knapweed, *Centaurea maculosa,* plants. Trace amounts of other species were observed. Plant cover present was insufficient to control erosion and provide soil stabilization.

Figure 6: Evidence of sparse vegetation on slopes before test plot construction.

Due to the steep slopes and lack of stabilizing post-construction vegetation cover, some rilling had occurred on the test site. After a field review, it was determined that additional raking or smoothing of the test site to prepare the seed bed was not necessary since the seedbed topsoil was loose and friable.

The two test plots that received the netting treatment, plot numbers 12 and 14, were prepared by removing the aerial portion of all existing vegetation to facilitate the spreading and attachment of the netting over the compost blanket. These two test plots were cleared of vegetation with a gas powered weed trimmer. The remaining 20 test plots did not receive any pre-seeding preparation except for the removal of the occasional noxious weed, primarily spotted knapweed. Cheatgrass was also present across the test site but these small ubiquitous exotic plants were not removed. Young cheatgrass plants had germinated and established on several of the plots and adjacent land as indicated by 1-3 cm tall stems.

Seeding of Test Plots

A native grass seed mix appropriate for the environmental conditions and soils at the research site was provided by the MDT Reclamation Specialist (Table 2). The seed mix was broadcast on each plot before the compost blanket was applied. Seed was broadcast using a hand held broadcast seeder to more readily adjust to variances in plot size and slope. Seed was weighed in individual bags for each test plot based on its area.

The seeding rate was identical for each of the 22 test plots. The bulk application rate was 0.45 kilogram (kg) or 1 pound of seed mix per 111.5 square (sq) m (1200 sq ft). In consultation with the MDT Reclamation Specialist, it was determined that bulk rates would not need to be adjusted for percent live seed due to the high seed viability percentages in the mix. Seed viability for the six native grass species varied from 90 to 99 percent (Table 2). This rate is comparable with broadcast seeding rates typically specified on MDT projects. Seed was supplied by Bruce Seed Farm, Townsend, Montana.

Table 2. Seed mix provided by MDT for use on test plots.

Species	**Scientific Name**	**Cultivar**	**Pounds**	**Percent of Mix**	**Viability**
Slender Wheatgrass	*Elymus trachycaulus*	Pryor	8.46	12.77	97
Canada Wildrye	*Elymus canadensis*		13.64	20.64	90
Sheep Fescue	*Festuca ovina*		4.2	6.45	96
Bluebunch Wheatgrass	*Pseudoroegneria spicata*	Goldar	21.69	32.93	94
Green Needlegrass	*Stipa viridula*	Lodorm	6.07	9.38	99
Indian Ricegrass	*Achnatherum hymenoides*	Nezpar	10.55	16.29	95

Compost Application

Compost was procured from Rocky Mountain Compost in Billings, Montana by Quality. A total of 30.6 cubic m (m^3)(40 cubic yards (yd^3)) was purchased. The total amount of compost required for the test plots was approximately 26.8 m^3 (35 yd^3), so excess material was purchased to ensure adequate compost was available. The compost procured was standard reclamation compost screened so that pieces were smaller than 1 cm (<3/8 in). When chemical analyses are complete a more detailed characterization of the compost will be provided in a future report.

Compost was applied with the use of a blower truck. The amount required for each plot was calculated based on plot area and the depth of the compost blanket to be applied. Compost depth on the test plots was controlled by operator/applicator experience and judgment. Before the applicator left the plot, the plot's compost depth was tested in random locations within the plot by one of the co-principal investigators.

Compost Retention Measures

Compost retention measures implemented as part of this project included three different tackifiers, one erosion control fabric, and one plastic netting product. For all five types of compost retention measures, the compost depth was 1.27 cm (0.5 in). First the plot was seeded, then, the compost was applied, and finally the retention material was deployed. All test plot compost and stabilization treatments are reported in Table 3.

Table 3: Test plot orientation, dimensions, treatments and steepness.

PLOT NUMBER	ASPECT facing slope	PLOT DIMENSIONS ft./m.	PLOT AREA sq. ft./sq. m.	TREATMENT	COMPOST DEPTH in./cm.	COMPOST VOLUME * yd^3/m^3	STEEPNESS % SLOPE
1	south	27 x 31 / 8.2 x 9.4	837 / 77.8	Inexpensive synthetic tackifier	0.5 / 1.27	1.5 / 1.1	71
2	south	30 x 32.5 / 9.1 x 9.9	975 / 90.6	Control	N/A	N/A	70
3	south	21 x 40 / 6.4 x 12.2	840 / 78.0	Dirt glue tackifier	0.5 / 1.27	1.5 / 1.1	66
4	south	30 x 28 / 9.1 x 8.5	840 / 78.0	Guar-based tackifier	0.5 / 1.27	1.5 / 1.1	64
5	south	29 x 30 / 8.8 x 9.1	870 / 80.8	Compost blanket only	0.25 / 0.625	0.8 / 0.6	64
6	south	27 x 30 / 8.2 x 9.1	810 / 75.3	Compost blanket only	0.5 / 1.27	1.5 / 1.1	65
7	south	27.5 x 30 / 8.4 x 9.1	825 / 76.6	Dirt glue tackifier	0.5 / 1.27	1.5 / 1.1	66
8	south	28 x 30 / 8.5 x 9.1	840 / 78.0	Compost blanket only	0.125/ 0.318	0.4 / 0.3	66
9	south	29 x 30 / 8.8 x 9.1	870 / 80.8	Compost blanket only	0.25 / 0.625	0.8 / 0.6	66
10	south	30.5 x 30 / 9.3 x 9.1	915 / 85.0	Erosion control fabric	0.5 / 1.27	1.5 / 1.1	66
11	south	30 x 56.5 / 9.1 x 17.2	1695 / 157.5	Compost blanket only	0.5 / 1.27	1.5 / 1.1	69
12	south	30 x 57 / 9.1 x 17.4	1710 / 158.9	Netting	0.5 / 1.27	1.5 / 1.1	67
13	south	30 x 59.5 / 9.1 x 18.1	1785 / 165.8	Control	N/A	N/A	69
14	south	30 x 62 / 9.1 x 18.9	1860 / 172.8	Netting	0.5 / 1.27	1.5 / 1.1	68
15	south	30 x 60.5 / 9.1 x 18.4	1815 / 168.6	Guar-based tackifier	0.5 / 1.27	1.5 / 1.1	66
16	south	30 x 57.5 / 9.1 x 17.5	1725 / 160.3	Inexpensive synthetic tackifier	0.5 / 1.27	1.5 / 1.1	68
17	south	30 x 53.5 / 9.1 x 16.3	1605 / 149.1	Compost blanket only	0.125/ 0.318	0.4 / 0.3	68
18	south	30 x 65 / 9.1 x 19.8	1950 / 180.2	Erosion control fabric	0.5 / 1.27	1.5 / 1.1	70
19	north	30 x 67 / 9.1 x 20.4	2010 / 186.7	Control	N/A	N/A	65
20	north	30 x 65.5 / 9.1 x 20.0	1965 / 182.6	Compost blanket only	0.25 / 0.625	0.8 / 0.6	64
21	north	30 x 65 / 9.1 x 19.8	1950 / 180.2	Compost blanket only	0.5 / 1.27	1.5 / 1.1	65
22	north	30 x 65 / 9.1 x 19.8	1950 / 180.2	Compost blanket only	0.125/ 0.318	0.4 / 0.3	65

* application rate per 1,000 square feet / 92.9 square meters

The first compost retention measure was an erosion control fabric produced by the manufacturer North American Green. It is comprised of straw and coconut fiber and meets federal specifications for an extended term erosion control blanket. According to the manufacturer's information sheet, this erosion control blanket is a 100 percent biodegradable blanket comprised of a 70 percent agricultural straw – 30 percent coconut fiber blend matrix with a functional longevity of up to 18 months. It must meet the requirements established by the Erosion Control Technology Council and the U.S. Department of Transportation, Federal Highway Administration's standard specifications for construction of roads and bridges on federal highway projects [FP-03 2003 Section 713.17, Type 3.B].

Rolls of the erosion control fabric were placed on top of the compost in overlapping applications and stapled/staked to the soil surface on test plots 10 and 18. The uppermost edge of the fabric was staked using wooden stakes and buried in an anchor-trench.

The second compost retention measure was a lightweight netting material produced by Filtrexx International, LLC (see www.filtrexx.com). This plastic green LockDown™ netting is not biodegradable and was provided by Quality and placed on top of the compost and held in place with metal sod staples. The manufacturer asserts that as "roots begin to penetrate the compost and netting layer, and sink into the substrate, they stabilize the entire system. Once fully rooted into the substrate, the netting provides long term extra stability."

It was noted the manufacturer of the netting recommends applying the netting directly to the soil and blowing the compost on top of the netting. An on-site discussion between the co-principal investigators and Quality reached concurrence that placing the netting on top of the compost blanket rather than under the compost blanket was likely to provide similar results. Since all other retention measures were placed on top of the compost blanket, this allowed this compost retention measure to be consistent with the four other types of treatments.

The last three compost retention measures used different commercially available tackifiers applied on 1.3 cm (0.5 in) compost blankets. Based on the experimental design (Table 1) the three tackifiers were 1) *DirtGlue*, 2) a guar-based adhesive, Supertack™, and 3) a relatively inexpensive synthetic adhesive. Discussions between the co-principal investigators and Quality led to a site-based decision to replace the synthetic tackifier with a plant-based adhesive, EM-Tack.

The three tackifiers are described by their respective manufacturer:

- *DirtGlue* is produced by Dirt Glue® Enterprises and is a polymer emulsion with bonding agents specifically engineered and formulated to bond soil particles together. According to the manufacturer, *DirtGlue* forms a protective, flexible film that eliminates dust, prevents mud, and controls erosion (see http://www.dirtglue.com/productinformation/);

- Supertack™ is produced by Rantec Corporation, it is a dispersible guar based tackifier comprised of a complex formulation of high quality water soluble polysaccharide and other proprietary ingredients made from natural non-toxic ingredients (see http://www.ranteccorp.com/prod_supertack.htm); and,
- EM-Tack is also produced by Rantec Corporation but does not have guaranteed quality. EM-Tack is a plant based mulch tackifier manufactured from *Psyllium* or *Plantago* husk powder. *Plantago* or *Psyllium* husk powder contains a naturally evolved mucilloid that is an effective adhesive when applied as a slurry with fiber or paper mulch or as an overspray to bond straw fiber (http://www.ranteccorp.com/prod_plantago.htm).

Both the EM-Tack and Supertack™ products were dry powders while *DirtGlue* was a thick liquid. The manufacturers' specifications listed the amount of product to be applied per area of treatment. The manufacturers gave broad guidelines for the volume of water needed to dissolve and deliver the tackifier solution. After a discussion between the principal investigators and Quality, the base application rate of liquid solution - a mix of water and the tackifier - was set at 378 liters (l) (100 gallons (gal)) of mixture per 92 sq m (1,000 sq ft) to allow the compost blanket to be adequately saturated by the solution. The volume of liquid solution was adjusted for each test plot based on the area of the plot (Table 4).

Table 4: Tackifier treatments for test plots.

Plot Number	Tackifier Brand	Product Quantity	Tackifier and Water Volume Applied	Plot Area (sq. ft./sq. m.)
Plot 1	EM-Tack	1.25 kg (2.75 lbs)	306 l (81 gal)	837/77.8
Plot 3	Super Tack®	1.25 kg (2.75 lbs)	306 l (81 gal)	840/78
Plot 4	Dirt Glue	23.5 l (6.2 gal)	341 l (90 gal)	840/78
Plot 7	Super Tack®	1.25 kg (2.75 lbs)	306 l (81 gal)	825/76.6
Plot 15	Dirt Glue	49.2 l (13 gal)	715 l (189 gal)	1815/168.6
Plot 16	EM-Tack	2.9 kg (6.37 lbs)	715 l (189 gal)	1725/160.3

For each of the test plots employing tackifier, the plot was seeded and then the compost was applied using the blower truck. This was followed by the spraying of the tackifier solution on top of the compost blanket. The tackifier solution was applied using a hose and nozzle attached to the hydromulch truck. It was applied in amounts that required several passes back and forth over the compost blanket; this allowed time for the tackifier solution to be absorbed by the compost and minimized any runoff of the solution from the steep slope. The application rate and technique successfully allowed the solution to saturate the compost blanket as well as seep through the blanket to create a bond with the surface of the soil.

CONCLUSIONS

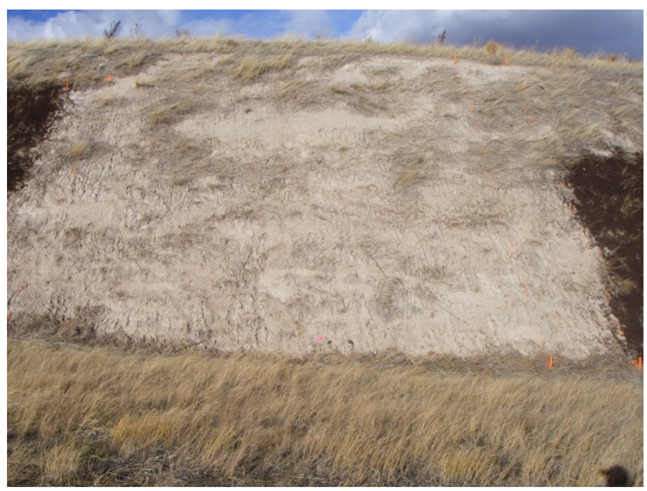
Tasks B and C have now been completed. Research plots were constructed adjacent to Montana Highway 84 on steep cut slopes during the week of 10 November 2008. Twenty-two test plots were constructed with only one adjustment made to the experimental design, a plant-based tackifier was substituted for the synthetic tackifier. Experimental treatments evaluate varying depths of compost; from 0.318 to 1.27 cm (0.125 to 0.5 in) and the effect of aspect, north-facing versus south-facing slopes. Additional test plots were implemented to evaluate the relative effectiveness of five different techniques to retain compost blankets on steep slopes against wind and water erosion. Three tackifiers, an erosion control blanket, and compost retention netting were used to stabilize 1.27 cm (0.5 inch) compost blankets on south-facing slopes. Test plots will be monitored for vegetation condition and erosion control during the 2009 and 2010 growing seasons.

REFERENCES

English, A. 2007. Overview of the Hydrogeology of the Gallatin Valley, prepared for the 2007 Montana Legislature Water Policy Interim Committee. http://leg.mt.gov/content/committees/interim/2007_2008/water_policy/meetings/minutes/wpic08162007_ex13.pdf

Montana State University, Reclamation Research Unit. 2007. Evaluation of Organic Matter Addition and Incorporation on Steep Cut Slopes, Phase II Test Plot Construction and Monitoring. MDT Research Division, Technical Report, Helena, MT.

APPENDIX A: IMAGES OF PLOTS BEFORE AND AFTER CONSTRUCTION

	
Plot 1 Before Construction	Plot 1 After Construction
	
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	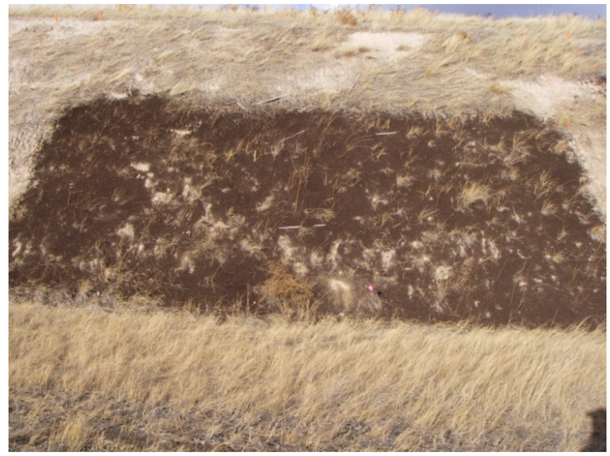
Plot 3 Before Construction	Plot 3 After Construction
	
Plot 4 Before Construction	Plot 4 After Construction

	
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	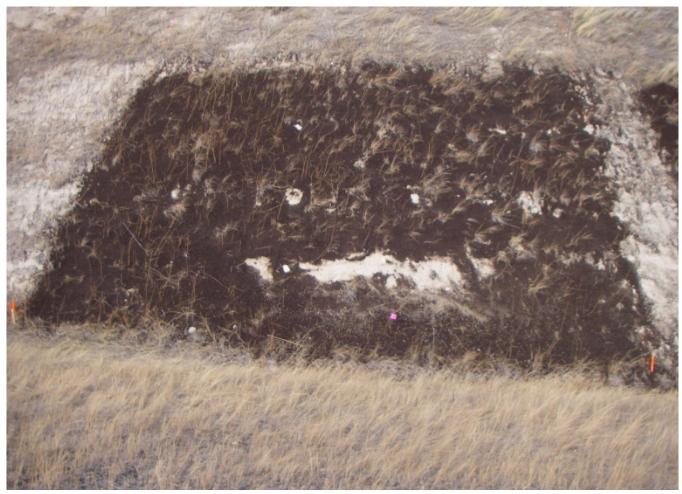
Plot 6 Before Construction	Plot 6 After Construction

	
Plot 7 Before Construction	Plot 7 After Construction
	
Plot 8 Before Construction	Plot 8 After Construction

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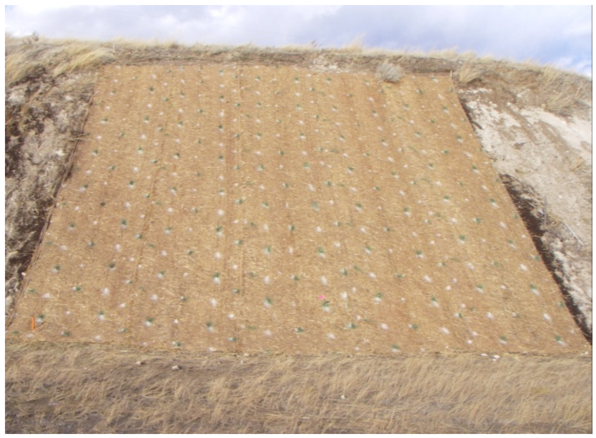
<tr><td></td><td></td></tr>
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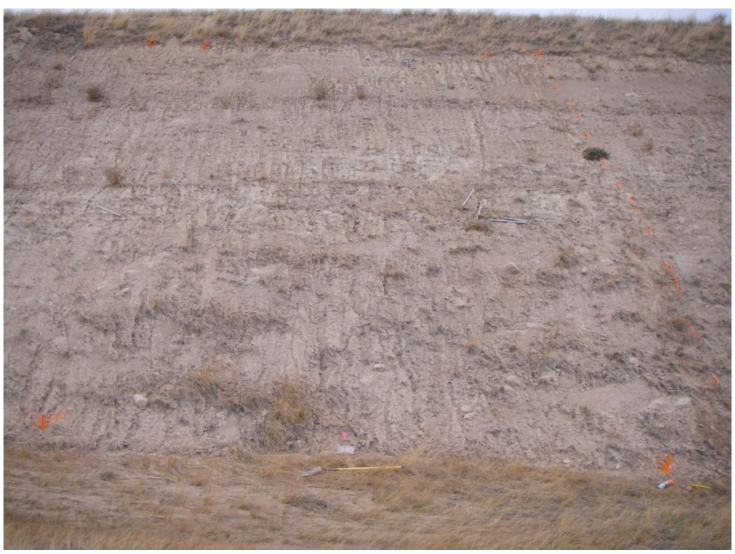	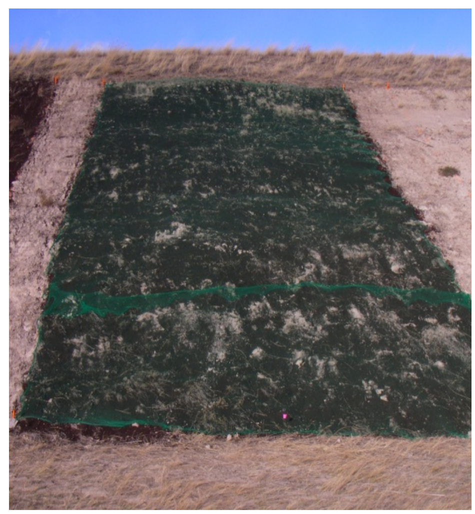
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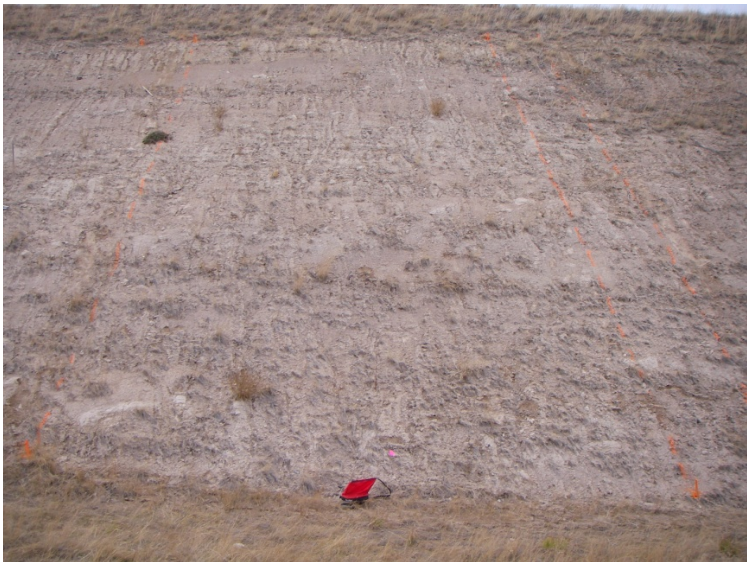	
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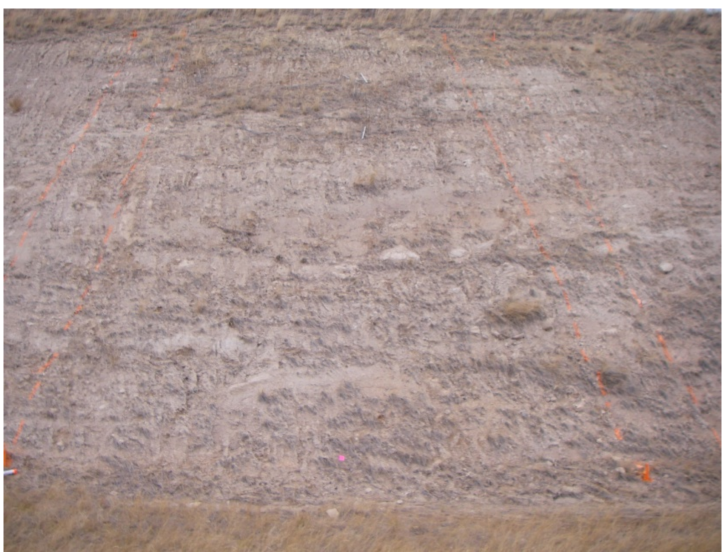	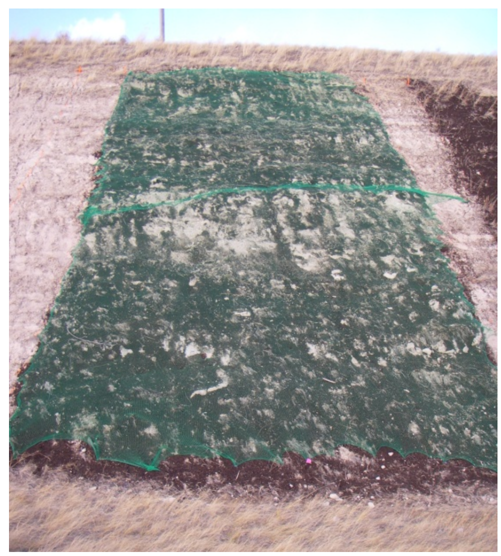
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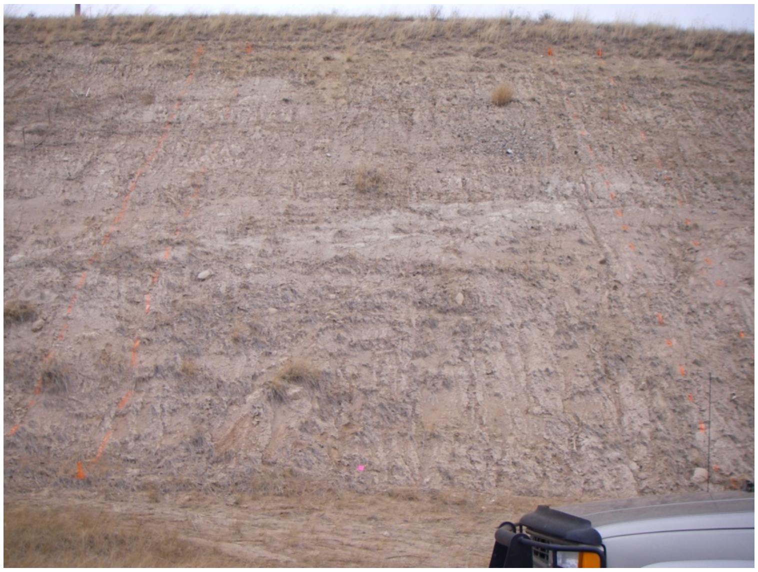	
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Plot 16 Before Construction	Plot 16 After Construction

	
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	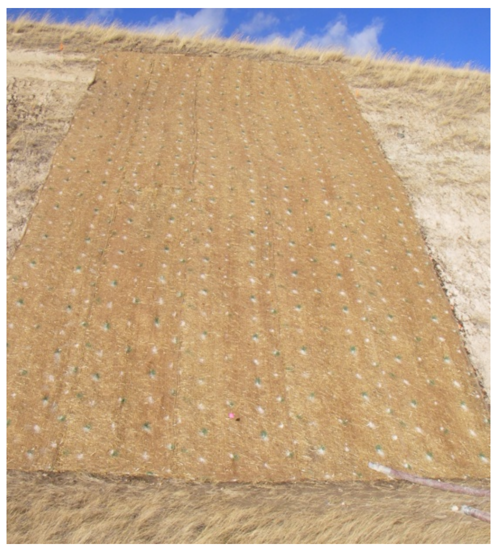
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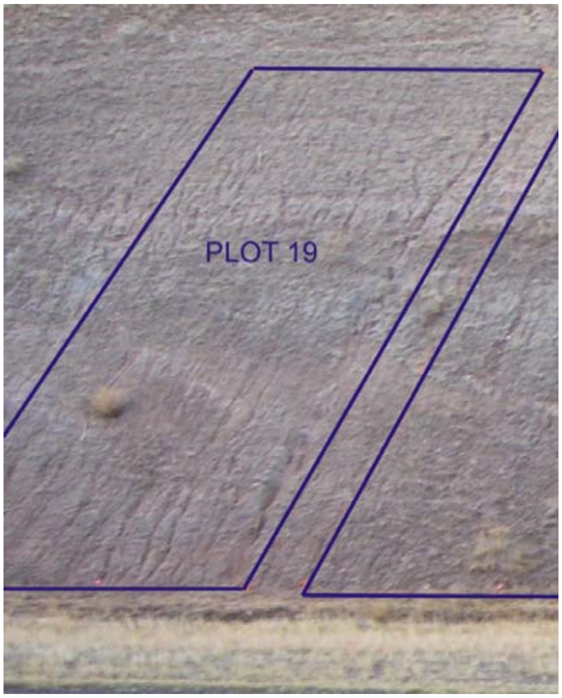
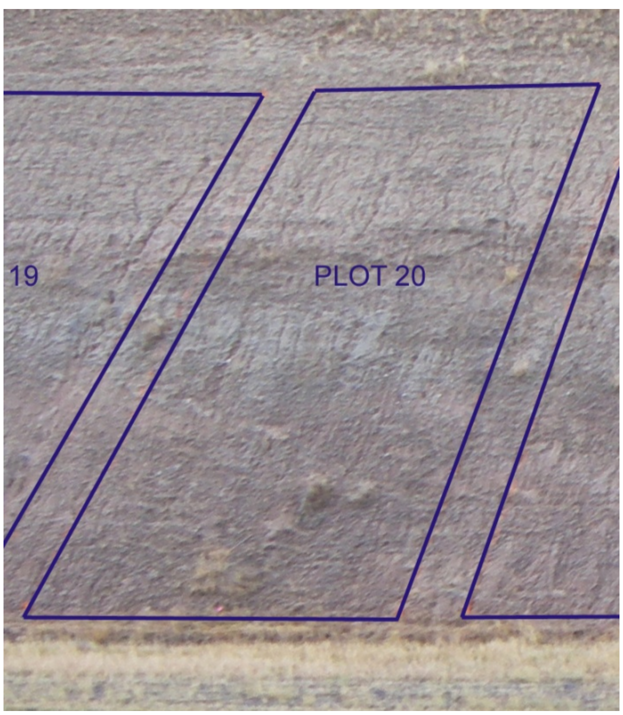


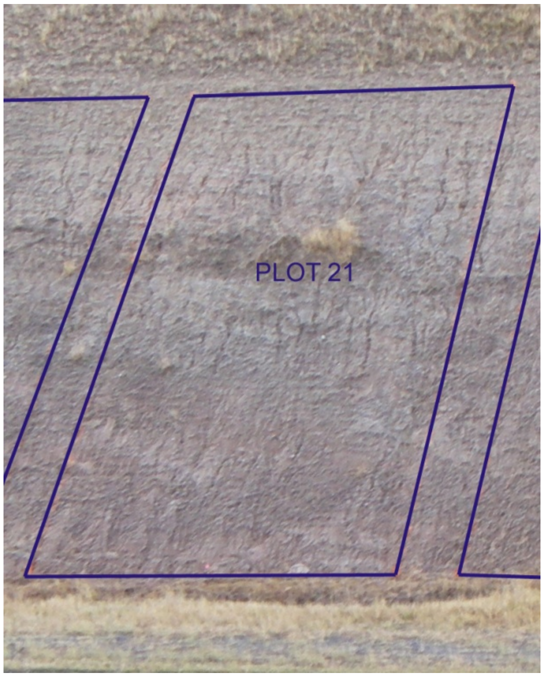
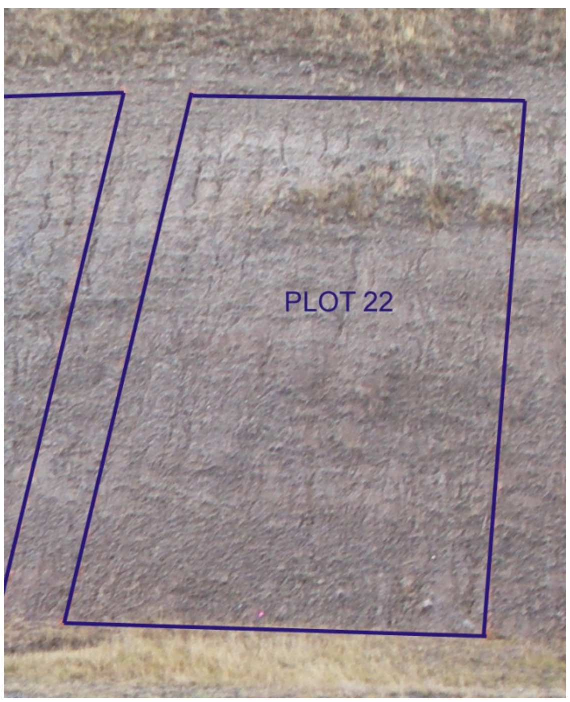
Plot 19 Before Construction

Plot19 After Construction



Plot 20 Before Construction

Plot 20 After Construction

	
Plot 21 Before Construction	Plot 21 After Construction
	
Plot 22 Before Construction	Plot 22 After Construction